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Standard Methods of Testing
MATERIALS FOR USE AS VAPOR BARRIERS UNDER CONCRETE SLABS AND AS GROUND COVER IN CRAWL SPACES[1]

This standard is issued under the fixed designation E 154; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

$^{\epsilon 1}$ NOTE—Section 2 was added editorially and subsequent sections renumbered in June 1985.

1. Scope

1.1 These methods[2] cover the determination of the properties of flexible membranes that are related to the serviceability of vapor barriers, when such membranes are used under concrete slabs and as ground cover in crawl spaces. The methods are applicable to such materials as asphalt-treated papers and felts, plastic films, and flexible sheets, for use at or near the finished grade level and where there is no reason to expect them to be subjected to hydrostatic pressure. The procedures covered in Sections 7 to 21 simulate the conditions to which a vapor barrier may be subjected. The procedures covered are:

	Sections
Water-Vapor Transmission of Material as Received	6
Resistance to Transmission of Water Vapor After Alternate Wetting and Drying and to Deterioration from Long-Time Soaking	7 and 8
Wet Tensile Strength	9 and 10
Resistance to Decay	11 and 12
Resistance to Puncture	13 and 14
Resistance to Plastic Flow and Elevated Temperature	15 and 16
Resistance to Deterioration from Petroleum Vehicle for Soil Poisons	17 and 18
Effect of Low Temperatures on Bending	19 and 20
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2. Applicable Documents

2.1 *ASTM Standards:*

D 828 Test Method for Tensile Breaking Strength of Paper and Paperboard[3]

E 96 Test Methods for Water Vapor Transmission of Materials[4]

3. Significance and Use

3.1 For vapor-barrier materials to be used under concrete slabs resting on the ground or as a ground cover in crawl spaces under basementless houses, the basic property desired is high resistance to water-vapor transmission. During installation and in service, the vapor barrier is subjected to conditions that may affect its proper functioning. It is important, therefore, that the barrier material have certain other physical properties, including strength and resistance to deterioration, to permit long service life. These test methods cover accelerated test procedures for evaluating materials for use as vapor barriers.

4. Sampling

4.1 Obtain samples for preparation of test specimens from each of three separate rolls or packages of each type of material being tested. Samples shall be representative of the material being tested and shall be of uniform thickness. If the samples are of nonsymmetrical construction, designate the two faces by distinguishing marks; for example, on a sample coated on one side, "I" for the coated side and "II" for the uncoated side.

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[1] These methods are under the jurisdiction of ASTM Committee E-6 on Performance of Building Constructions and are the direct responsibility of subcommittee E06.21 on Serviceability.

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[2] These methods are based largely on the Forest Products Laboratory Report No. 2040 and the Building Research Advisory Board report, "Vapor Barrier Materials for Use with Slab-On-Ground Construction and as Ground Covers in Crawl Spaces."

[3] *Annual Book of ASTM Standards*, Vol 15.09.

[4] *Annual Book of ASTM Standards*, Vol 04.06.

5. Test Specimens

5.1 The number and size of test specimens of each material are specified in each test procedure. One specimen for each test shall be prepared from each of the three samples (Section 4). Great care should be taken to protect the test areas of the specimens against damage or contamination.

WATER-VAPOR TRANSMISSION OF MATERIAL AS RECEIVED

6. Procedure

6.1 Make water-vapor transmission tests on at least three specimens of each material in accordance with Procedure B or D of Test Methods E 96 (Note 1). If the barrier metal is coated or treated on one surface to improve its water-vapor resistance, make the test with this surface toward the water unless otherwise specified.

NOTE 1—Where wax seals are used with the wet method, it is highly desirable to heat the test dishes adequately before sealing the test sample to the dish.

RESISTANCE TO TRANSMISSION OF WATER VAPOR AFTER ALTERNATE WETTING AND DRYING AND TO DETERIORATION FROM LONG-TIME SOAKING

7. Apparatus

7.1 *Controlled-Temperature Vessels*, of suitable size for soaking specimens, and equipped with a temperature controller actuated by a thermostat. The controller shall be of a type that will maintain temperature in the vessels at 73.4 ± 3.5°F (23 ± 2°C). If space permits, the test chamber used for the water-vapor transmission tests may be used to hold soaking plans in place of the thermostatically controlled vessel.

7.2 *Oven or Drying Chamber*, for drying test specimens, thermostatically controlled at a temperature of 140 ± 3.5°F (60 ± 2°C).

7.3 *Water-Vapor Transmission Apparatus*, as prescribed in Test Methods E 96.

7.4 *Mandrel*—A bar or rod 1 in. (25 mm) in diameter and 18 in. (457 mm) long.

8. Procedure

8.1 Cut three specimens, 12 by 12 in. (305 by 305 mm) of the material to be tested.

8.2 Immerse the specimens in potable water kept at a temperature of 73.4 ± 3.5°F (23 ± 2°C) for 16 h (overnight). Then dry the specimens in an oven kept at 140 ± 3.5°F (60 ± 2°C) for 8 h. Repeat the wetting and drying cycle for a total of 5 cycles (Monday through Friday) to be followed by immersing the specimens in water over the week end (64 h). Repeat the wetting and drying cycle 5 more days and immerse the specimens in water for a period of 16½ days (week end plus 2 weeks). Dry the specimens at 140 ± 3.5°F (60 ± 2°C) for 8 h; then condition to a constant weight in the chamber where water-vapor transmission tests are made.

8.3 Cut the specimens in half, parallel to the machine direction (the long direction as taken from the roll or package). Bend one of the halves of each specimen with one surface up and the other specimen with the opposite surface up at an angle of 90° of a 1-in. (25-mm) diameter mandrel in a period of 2 s or less (at 73.4°F, 23°C). Record evidence of cracking or delamination.

8.4 Cut specimens for the water vapor transmission test so that the full bent portion is installed in the center of the pan with the surface that was concave at the time of bending facing the water. Determine water vapor transmission in accordance with Section 5.

WET TENSILE STRENGTH

9. Apparatus

9.1 *Controlled-Temperature Vessels*—See 7.1.

9.2 *Testing Machine*—A pendulum-type tension testing machine such as is described in Test Method D 828, or the equivalent.

10. Procedure

10.1 Cut ten specimens, 1 in. (25 mm) wide and 8 in. (203 mm) long, in each principal direction (crosswise and lengthwise) of the sample.

10.2 Immerse in potable water controlled at a temperature of 73.5 ± 3.5°F (23 ± 2°C) for 7 days in such a manner that water has free access to all surfaces and edges of the specimens.

10.3 Remove the specimens from the water one at a time, lightly blot the free water from both surfaces, and immediately determine the tensile strength and stretch at maximum load.

Test both sets of specimens at a temperature of 73.4 ± 3.5°F (23 ± 2°C) with the tester adjusted so the distance between the jaws is about ½ in. (13 mm). The jaws of the clamp should be lined with emery cloth or other material to prevent slipping of the specimen during test. Materials with very little stretch may be tested with a requirement for tensile strength only. Materials with high stretch may be tested with a requirement for energy absorbed to maximum load, in inch-pounds or other convenient unit. Average the ten readings, crosswise and lengthwise, respectively.

RESISTANCE TO DECAY

11. Apparatus and Materials

11.1 *Incubation Chamber or Room,* maintained at a temperature of 80 ± 3°F (27 ± 2°C) and a relative humidity of 70 ± 3 %.

11.2 *Soil Containers,* consisting of nonporous dishes or pans, four for each biological test of each material being tested; a container that will accept a specimen as large as 6¼ in. (159 mm) in diameter and deep enough to hold 3 in. (76 mm) of soil. (The soil may be mounded if necessary to obtain the 3-in. depth.) The dishes or pans should have covers of some nonporous material such as glass, metal foil, or 6-mil (0.15-mm) polyethylene. Covers are intended to retard evaporation, but should not be so tight that they prevent access of air into the container. Disposable type aluminum baking pans and pie-plate covers can be obtained in suitable size.

11.3 *Sieves,* No. 6 (3.35-mm) and No. 10 (2.00-mm).

11.4 *Spatula.*

11.5 *Soil and Its Preparation*—Soil, of high microbial activity, such as greenhouse specialists term potting soil, rich in cellulose-destroying organisms, and meeting the following additional requirements:

11.5.1 Potting soil containing approximately equal parts by volume of well-rotted barnyard manure, loam top soil, and coarse sand should be generally adequate. Since the soil is depended on for microbiological activity, it is very important that it should not be sterilized; if purchased, therefore, *unsterilized soil* should be carefully specified. The soil should have the following additional characteristics:

11.5.1.1 A particle size obtained by sifting through a No. 6 (3.35-mm) sieve. To facilitate sifting, the soil should be in good working condition, that is, neither particularly wet nor dry.

11.5.1.2 A pH in the range from 5.5 to 7.0.

11.5.1.3 A moisture content as great as can be tolerated and still keep the soil from forming into large lumps, so that it stays in a condition permitting it to be scooped up in uniform amounts for transfer to the soil pans. With many potting soils, the proper amount of moisture can be determined on small batches by adding a little water at a time as the soil is stirred; it probably will be between 30 and 35 % of the oven-dry weight of the soil. Water to be added should be distilled or so low in akalinity that it will not take the soil out of the specified pH range. The added water should be thoroughly mixed into the soil, which will serve to provide a uniform distribution of both moisture and the solid soil constituents. Adequate mixing of all the soil to be used in connection with vapor barrier materials being compared at one time is essential so that the materials will all be exposed to soil of essentially the same microbiological activity.

11.6 *Veneer Sample Cards,* 3 by 3 by 1/16-in. (76 by 76 by 1.6-mm) of sweetgum-sapwood veneer, for determining the duration of test according to the microbiological activity of the soil.

11.7 *Test Specimens*—The test membranes shall be circular and of the same diameter as the test specimens required for the water-vapor transmission test in 12.4. Four samples of each membrane shall be tested.

12. Procedure

12.1 *Burial and Incubation of Specimens*—Bury the specimens, without folding or wrinkling, using the following steps:

12.1.1 Put soil carrying the required amount of water (see 11.5) in the soil pan to a depth of approximately 1½ in. (38 mm) and level the surface under light compression that will eliminate any surface lumps.

12.1.2 Place the test specimen on the soil, centering it approximately.

12.1.3 Add an additional 1½ in. (38 mm) of soil and level or slightly mound the surface with light compression as before. It is important that the soil contact the entire upper and lower surface areas of the test specimens; hence the need for some compression.

12.1.4 Cover the pans containing the soil beds and specimens thus prepared and hold them for a period, as determined by the microbiological activity of the soil (see 12.2), in a darkened chamber or room having a temperature of 80 ± 3°F (27 ± 2°C) and a relative humidity of 70 ± 3 %.

12.2 *Standardization of Test Duration According to Microbiological Activity of Soil*—Place under test, at the same time and in the same way as hereafter described for the membranes to be tested, cards of 1/16-in. (1.6-mm) sweetgum-sapwood veneer that have been conditioned to a constant weight, and weighed, at the same temperature and relative humidity as maintained in the chamber where vapor transmission tests are made in accordance with 12.4. Conditioning should take approximately 24 h and the cards should have a moisture content of about 9 %. Remove individual cards from the test at intervals to establish a weight-loss trend. Gently wash the cards free of soil and again condition before weighing. When the trend of veneer-card weight losses indicates a weight loss not less than 35 % of the initial card weight, the test may be characterized as standard for appraising permeance stability and may be terminated. Control in this respect can be guided by using a small surplus of veneer cards and removing one from test at suitable intervals, beginning at about the fourth week. If appraisal of the long-term persistence of membrane strength as well as permeance is important, it is advisable to carry out the test on a second set of membranes and to continue the test until the veneer cards have incurred a weight loss of about 65 %.

12.3 *Dismantling of Test*—At the end of the incubation period (1.1), carefully remove the specimens and wash them free of soil. Take precautions both here and in preceding steps to avoid any damage to the surfaces in handling that might significantly affect subsequent testing of permeability of the membrane.

12.4 *Measurement of Results*—Weigh test specimens before and after the soil-burial test. Condition the test material to a constant moisture content as required for the water-vapor transmission test before each weighing. Determine water-vapor transmission rate on the test specimens in accordance with Test Methods E 96, as directed in Section 6. Judge loss of membrane strength by the reduction in weight of the specimen.

RESISTANCE TO PUNCTURE

13. Apparatus

13.1 *Wooden Frame*, having 10 by 10-in. (254 by 254-mm) outside measurement and 6 by 6-in. (152 by 152-mm) opening, and consisting of two parts, each 1¼ in. (32 mm) thick, that are held together with eight thumbscrews, two on each side. The contact face of each part shall be surfaced with sandpaper to prevent slipping of the sheet being tested.

13.2 *Steel Cylinder*, solid, 1-in. (25-mm) diameter, with the edge of the end surface slightly rounded.

14. Procedure

14.1 Cut three 10-in. (254-mm) square specimens of the material to be tested. Condition specimens at 73.4 ± 3.5°F (23 ± 2°C) and 50 % relative humidity to a constant weight.

14.2 Place a single sheet between the upper and lower parts of the wooden frame and tighten the thumbscrews.

14.3 Bring the end surface of the solid steel cylinder into contact with the sheet being tested. Lower the cylinder at a rate of 0.25 in. (6 mm)/min. Continue the test until maximum load is reached. Make the tests at a room temperature of 73.5 ± 3.5°F (23 ± 2°C).

14.4 Record the maximum load and stretch at maximum load. Also note the type of failure.

14.5 Average the values for the three tests.

RESISTANCE TO PLASTIC FLOW AND ELEVATED TEMPERATURE

15. Apparatus

15.1 *Crushed Rock*, ¾-in. (19-mm) size, to a depth of at least 2 in. (51 mm) in suitable containers not less than 7 in. (178 mm) square and 3⅝ in. (92 mm) deep. The crushed rock shall be relatively uniform in size, passing through a ¾-in. sieve and retained on a ½-in. sieve.

15.2 *Conditioning Chamber*, thermostatically controlled at a temperature of 140 ± 3.5°F (60 ± 2°C) and maintained with a relative humidity of 30 ± 2 %.

16. Procedure

16.1 Cut three 6-in. (152-mm) square specimens of the material to be tested and condition to a constant weight at a temperature of 73.5 ± 3.5°F (23 ± 2°C) and at a relative humidity of 50

± 2 %. Place the specimens, treated or coated side down, over carefully leveled crushed rock in containers, conforming to 15.1, and cover each specimen with a 6 by 6-in. (152 by 152-mm) platen made of ¾-in. (19-mm) plywood. Load the platen with a weight of 25 lb (11 kg). Condition the assembly for 28 days at a temperature of 140 ± 4°F (60 ± 2°C) and a relative humidity of 30 ± 2 %.

16.2 Make a water-vapor transmission test of each specimen, with the unabraded surface toward the water, in accordance with Test Methods E 96.

RESISTANCE TO DETERIORATION FROM PETROLEUM VEHICLE FOR SOIL POISONS

NOTE 2—The vehicle used in soil poisons intended for termite control may cause deterioration to some vapor-barrier membranes. Ordinarily, the chemicals are used in a diluted form and are unlikely to occur in sufficient concentration to cause damage. The vehicle used with most poisons is water when temperatures at time of use will not cause freezing problems, but when temperatures are too low to permit the use of water, petroleum products such as fuel oil, kerosene, or naphtha may be substituted. Some proprietary poisons can be used only with petroleum product vehicles. Petroleum oils may cause more or less damage to membranes containing asphalt that are in contact with or even exposed to vapor from the oils. Other membranes may also be affected by long exposure to petroleum vehicles.

17. Apparatus and Materials

17.1 *Containers,* consisting of glass, graniteware, or earthenware crocks at least 9 in. (228 mm) square and 3 in. (76 mm) deep. Aluminum-foil covers for the containers.

17.2 *Constant-Temperature Room or Incubator,* in which temperatures can be maintained between 80 and 90°F (27 and 32°C).

17.3 *Testing Machine*—See 9.2.

17.4 *Soil*—A supply of potting soil that has been sterilized by steaming or autoclaving for 30 min at atmospheric pressure.

18. Procedure

18.1 Cut and prepare four specimens, each not less than 8 by 8 in. (203 by 203 mm). Condition specimens to a constant weight under the conditions required for the water-vapor transmission test in accordance with 18.4, and record this weight.

18.2 To air-dry soil conforming to 17.4, add No. 1 fuel oil in small quantities, mixing it thoroughly until the oil content is as high as can be tolerated without making the soil sticky or muddy. Prepare an exposure bed with such soil in containers conforming to 17.1. The first layer of soil shall be 1 in. (25 mm) deep and carefully smoothed or leveled. Place a specimen over the soil and add another 1-in. layer of soil. If the depth of the dish is adequate, additional specimens may be added, provided each specimen is covered with 1 in. of the soil mixture.

18.3 Cover the dishes with aluminum foil covers and store them in a room having a temperature of 80 to 90°F (27 to 32°C) for 10 days.

18.4 After the exposure period, remove the specimens from the dishes, brush off dirt, and condition them to a constant weight as in 18.1. Weigh the specimens and record the weight. Cut a section from each specimen and determine the water vapor transmission in accordance with Test Methods E 96, as directed in Section 6. Also, cut two pieces 1 in. (25 mm) wide and 6 in. (152 mm) long from each test specimen in each principal direction (crosswise and lengthwise) of the specimen and test for tensile strength and stretch at maximum load as directed in 10.3.

EFFECT OF LOW TEMPERATURES ON BENDING

19. Apparatus

19.1 *Controlled-Temperature Chamber,* maintained at a temperature of 20 ± 3.5°F, (−6.7 ± 2°C).

19.2 *Mandrel*—See 7.4.

20. Procedure

20.1 Cut three 12 in. (305 mm) square specimens of the material to be tested.

20.2 Cut the specimens in half, parallel to the machine direction (the long dimension as taken from the roll or package). Place the specimens and the 1-in. (25-mm) mandrel in a chamber maintained at 20 ± 3.5°F (−6.7 ± 2°C) for at least 24 h.

20.3 Bend one of the halves of each specimen with one surface up and the other half with the opposite surface up at an angle of 90° over the mandrel in a period of 2 s or less. The specimens and the mandrel shall be in the chamber when bends are made. Record evidence of cracking or delamination.

20.4 Cut specimens for the water-vapor transmission test to include the bent portion and install them in pans with the surface that was concave at time of bending facing the water. Determine water vapor transmission in accordance with Test Methods E 96, as directed in Section 6.

REPORT

21. Report

21.1 The report shall include the following:

21.1.1 A complete description of the material tested.

21.1.2 Water vapor transmission of the material as received (Section 6), expressed as permeance.

NOTE 3—Permeance expresses the relation of the rate of water vapor transmission to the vapor pressure difference across the specimens and is expressed in perms, where a perm equals the grains of moisture transmitted per hour per square foot at a pressure differential equivalent to 1 in. (25 mm) of mercury.

21.1.3 Water vapor transmission after alternate wetting and drying (Section 8), expressed as permeance.

21.1.4 Resistance to deterioration from long-time soaking, as shown by:

21.1.4.1 Evidence of cracking or delamination (8.3), and

21.1.4.2 Water vapor transmission (8.4), expressed as permeance.

21.1.5 Wet tensile strength and stretch at maximum load (Section 10).

21.1.6 Water vapor transmission after exposure in the resistance to decay test (Section 12), expressed as permeance.

21.1.7 Maximum load and stretch at maximum load in the test for resistance to puncture (Section 14).

21.1.8 Water vapor transmission after exposure in test for resistance to plastic flow and elevated temperature (Section 16), expressed as permeance.

21.1.9 Resistance to deterioration from petroleum vehicle for soil poison (Section 18), as shown by:

21.1.9.1 Change in weight,

21.1.9.2 Water vapor transmission, expressed as permeance, and

21.1.9.3 Tensile strength and stretch at maximum load.

21.1.10 Effect of low temperatures on bending, as shown by:

21.1.10.1 Evidence of cracking or delamination (20.3), and

21.1.10.2 Water vapor transmission (20.4), expressed as permeance.

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